ON THE INFLUENCE OF EARTHWORMS ON THE SOIL STRUCTURE IN MULCHED ORCHARDS

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Fruit growing needs a high level of physical and chemical fertility of the soil. In this paper, in particular the physical properties of the soil will be discussed. In the Netherlands the water requirement of fruit trees is larger than the average precipitation during the growing season. This shortage in water must be supplied by the reserve of moisture in spring or out of the groundwater by capillary forces. In both cases it is desirable that roots can penetrate deeply into the soil and therefore a heterogeneous porosity is necessary. Active hairroots need air and water and this is only present on sites where the larger pores contain air and the smaller ones water. Because for the plants a tension of the groundwater between pF 2 and 3 is desirable pores with an approximate diameter between 3 and 30 microns are needed. In some soils the occurrence of such pores is determined by their texture, for example loessoid soils and marine silt soils, but most of the soils depend on their structure for this pore size. Then the pores are made by small animals such as eel worms or are abandoned rootchannels. A good supply of air is made possible only by continuous pores of larger than 30 microns in diameter, and in soil with a good moisture holding capacity these are only present by the aid of biological activity.

In general we can say that without biological activity the pores in the soil are determined by the mutual arrangement of the mineral constituents, in which case only 30 % — 40 % of the total volume remains available for air and water. In good soils air and water have for their disposal 60 % — 70 % of the total volume. If in these soils the water volume is maximal ± 40 %, there always remains 20 % — 30 % for air (fig. 1). In soils having a poor structure the air volume can diminish to nearly zero.

So fruit trees prefer soils with a high biological activity. This is known by all fruit growers and they try to stimulate biological life by administering of organic food. When stable manure is not available or too expensive, they do it with green manures of grass mulch.

To determine the influence of the grass mulch on the soils we had to compare a mulched orchard with an orchard without any undergrowth, without any herbaceous vegetation and without administering any organic food. In the latter case the advantage is, that the fruit trees need not compete with the other plants for mineral nutritients and water, but the soil must be cultivated frequently to prevent the growth of weeds and to control direct evaporation, which is expensive. The organic matter content of the soil becomes lower and lower and due to rain and mechanical pressure all larger pores disappear. Moreover difficulties arise over the uptake of the minor elements.

The grass mulch is only possible on fertile and moist soils. Mowing grass is cheaper than clean weeding. The grass mulch gives a prevention against structure deterioration through rainfall and mechanical pressure. But the most important effect is the stimulating of the active structure building processes, with the aid of the earthworms. These are responsible for the major part of the pores between 1 and 8 mm. The smaller species live in the upper few feet of the soil, but the larger species go down to 4 and 5 feet. All species live in burrows in the soil, formed partly by the insertion and expansion of the pointed front segments of the body in interstices of the soil, and partly by actual ingestion of the earth. Some of the soil ejected at the hinder end after digestion is used to line the walls of the burrow particularly where it passes through sandy silt layers (fig. 3); the remainder is voided either in empty spaces below ground level or on the surface in the form of the familiar worm casts.

A quantity of earthworms with a weight of 2000 kg to the ha (± 1800 lbs to the acre) is not abnormal. It is quite possible that within a period of 5 years the whole topsoil has passed through the intestines of these creatures. As a result of the building-in of the protein nitrogen in thus formed humus the topsoil takes on a dark colour. This form of humus has a stabilizing action. Also along the wormholes in the subsoil the excrements are met with. All soils with an antropic B-horizon are influenced by the activity of earthworms. The coatings of humus are not due to passive eluviation out of the A-horizon, but are due to the active lining of the pores with the dark excrements of the earthworms.

Worms are susceptible to desiccation. In deeply drained silty to clayey soils the larger specimens crawl down to a depth of as much as 5 feet below surface, as a rule, until immediately above the groundwater table. Impermeable clay layers can loose their disturbing character in the course of time by this action. At a depth of 25 cm in a grass mulched soil we counted no less than 50 large earthworm voids (± 8 mm) on a quarter of a square meter, that means 800.000 per acre.

After 15-20 years of mulching practice the stability of the structure has notably improved. Disc-harrowing and tillage in general diminishes rapidly this slowly acquired improvement. Unlike the absorbed lime which is responsible for the floc structure, this form of humus gives rise to the aggregate structure, the cementation of the floccules.

The authors arrive at the following conclusions :

1. By means of the biological life in the soil the soil structure can be improved considerably. In the river clay soils under examination earthworms play the principal part.

2. Improvement of the structure manifests itself on the one hand by an increasing resistance against structure-demolishing agents, on the other hand by perforating compact layers causing an increase in the permeability and moisture holding capacity of the biologically influenced part of the soil.

3. The influence of life in the soil can be increased by administration of organic food. In orchards with an undergrowth of grass this can be performed advantageously by a decomposition on the spot of the mown grass.

4. With organic matter rich in protein, stable dark-coloured structural aggregates are formed by the earthworms. The structure-improving influence of the worms is greatest if they have at their disposal young grass rich in protein. Therefore it is recommendable not to let the grass grow too high.

5. By giving nitrogen in form of artificial fertilizer the soil structure can be improved markedly by way of grass mulch and the earthworms. The nitrogen administered to the soil will be partly tied to the humus. The expenses of the nitrogen administration should only be partly charged to the yearly cost of exploitation, as they should also be considered partly as an investment.

6. Tillage does not improve soil structure. By tillage not only are the living organisms damaged, but also the water-stability of the structure aggregates is strongly reduced, owing to loss of nitrogen of the organic matter.

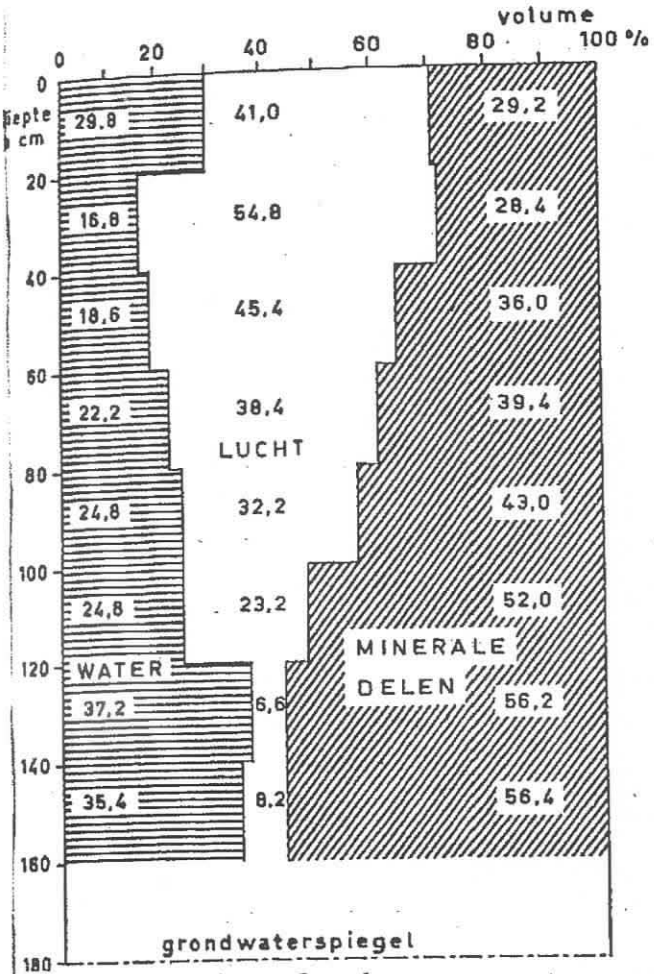

Fig. 1. Distribution of volume percentages of water, air and mineral parts in a pasture soil profile on the levee of the Kromme Rijn in which there is a great activity of earthworms and moles.

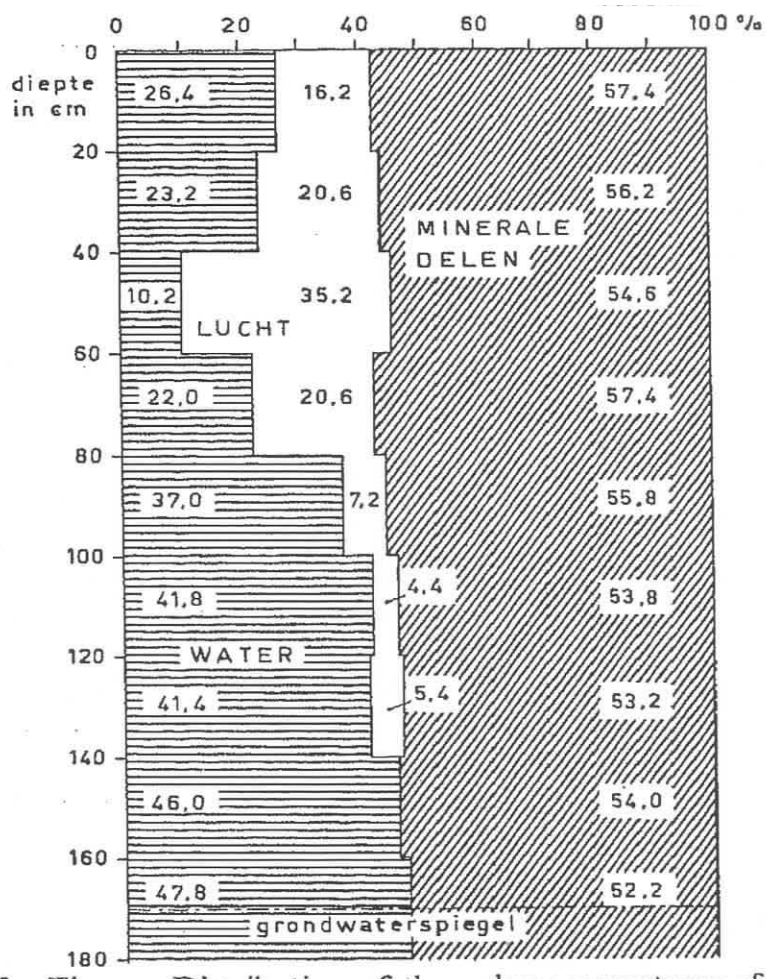

Fig. 2. Distribution of the volumepercentages of water, air and mineral parts in a sandy river clay soil. Pasture under cherries, sown 1 1/2 year before sampling. The compact topsoil shows clearly that a strong detioration of the soil structure has taken place after sowing. The compactness of the layer of 20-40 cm is also a consequence of the plow-sole originating of the arable land period. As mulching is not practiced on this profile the compactness caused by driving and treading cannot be eliminated by the living organisms in the soil. From 40-60 cm below surface a sandy layer occurs with a very low moisture-holding capacity. Under this layer the sand is finer and more silt containing by which more water occurs in these layers.

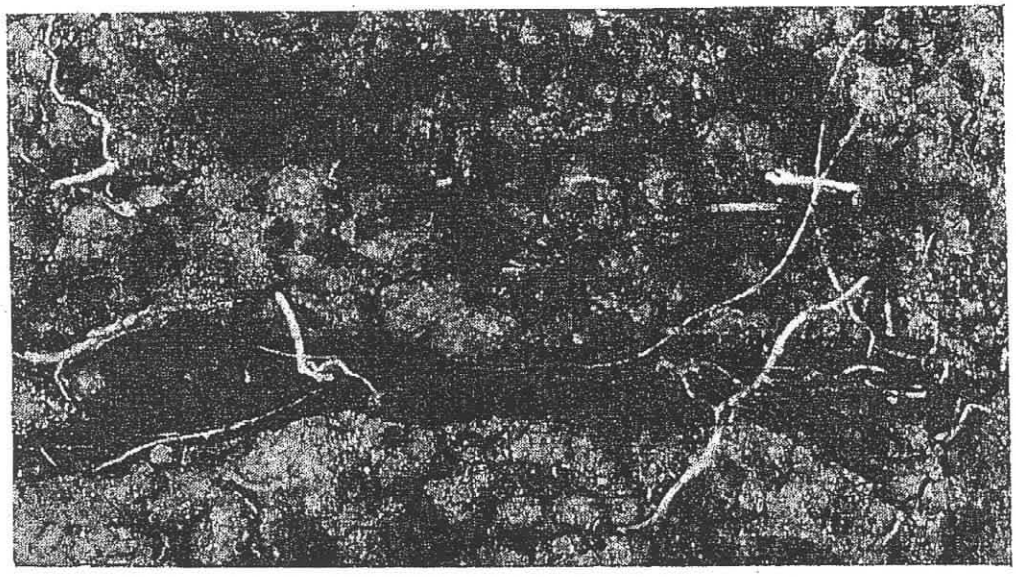

Fig. 3

Picture (enlarged 1,6 ×) of a good river clay soil at a depth of ± 10 cm. Some roots are penetrating the subsoil along an earthworm void. Mind the strongly rounded forms of the soil aggregates. Conspicuous is the dark humic plaster of the void.

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SAMENVATTING

De invloed van regenwormen op de bodemstructuur in gemulchte boomgaarden

1. De bodemstructuur kan merkelijk verbeterd worden door het biologisch leven in de grond. In de door ons onderzochte rivierkleigronden spelen de aardwormen de voornaamste rol.
2. De verbetering van de bodemstructuur kan vastgesteld worden, enerzijds door een verhoogde weerstand tegen de structuurvernietigende factoren en anderzijds door de aanwezigheid van wormgangen in de compacte lagen. De regenwormgangen verhogen de doorlatendheid en het waterbergend vermogen van de bodem.
3. De biologische activiteit in de bodem kan verhoogd worden door toediening van organisch materiaal. In een boomgaard met grasbestand kan toediening van organisch materiaal gemakkelijk gebeuren door het afgemaaide gras ter plaatse te laten vergaan.
4. Wanneer organisch materiaal rijk aan proteïnen voorhanden is, worden door aardwormen stabiele donkergekleurde aggregaten gevormd. De structuurverbeterende invloed van de aardwormen is het grootst wanneer ze jong gras, rijk aan proteïnen, ter beschikking kunnen hebben. Daarom is het aan te raden het gras regelmatig kort af te maaien.

5. Toediening van stikstof in de vorm van kunstmest, gepaard met de aanwezigheid van aardwormen en grasmulch, kunnen de bodemstructuur aanmerkelijk verbeteren. De toegediende stikstof wordt gedeeltelijk vastgelegd in het humuscomplex. Daarom moet slechts een gedeelte van de toegediende stikstof in de jaarlijkse exploitatiekosten opgenomen worden; het andere gedeelte moet beschouwd worden als een investering.
6. Bodembewerkingen verbeteren hier de bodemstructuur niet. Ze vernietigen niet alleen de levende organismen maar verminderen de waterstabiliteit van de aggregaten, doordat bodembewerking ook stikstofverlies van het organisch materiaal in de hand werkt.

RESUME

De l'influence des vers de terre sur la structure du sol sous verger à couverture morte (mulch)

1. La vie micro-biologique du sol peut améliorer la structure du sol de façon notable. On remarque que les vers de terres jouent un rôle important dans des sols argileux d'alluvion de rivière.
2. L'amélioration de la structure se révèle d'une part par un accroissement de la résistance aux facteurs dégradant la structure et d'autre part par la formation de galeries dans la couche compacte. Ces galeries augmentent la perméabilité ainsi que la capacité de rétention d'eau.
3. L'activité biologique du sol peut être accrue par un apport de matière organique. Dans les vergers à végétation herbagère, l'apport de matière organique peut être considérablement augmenté par la décomposition sur place de l'herbe fauchée.
4. Les vers de terre forment des agrégats foncés et stables dans les sols pourvus de matière organique riche en protéines. Les effets d'amélioration de structure sont les plus marquants lorsque les vers de terre disposent d'une jeune herbe riche en protéines. Par conséquent il est à conseiller de faucher l'herbe régulièrement.
5. La structure peut également être améliorée de façon notable par un mulch d'herbe et par les vers de terre lorsqu'on ajoute un apport d'engrais azoté. L'azote de l'engrais se liera en partie à l'humus. Par conséquent les achats de l'engrais azoté ne sont que partiellement à inscrire comme dépense annuelle de l'exploitation et partiellement à titre d'investissement.
6. Les méthodes aratoires n'améliorent pas la structure du sol dans ce cas. Les labours portent non seulement préjudice aux organismes vivants, mais diminuent également, et de façon notable, la stabilité des agrégats. Cet effet est d'autant plus évident que les labours provoquent une perte de l'azote lié à la matière organique.

ZUSAMMENFASSUNG

Uber den Einfluss der Regenwürmer auf die Bodenstruktur in bedeckten (mulched) Baumgärten

1. Durch das Bodenleben kann die Bodenstruktur erheblich verbessert werden. In den hier untersuchten tonigen Böden (Flusston) spielen die Regenwürmer die wichtigste Rolle.
2. Die Bodenstrukturverbesserung kommt einerseits durch einen zunehmenden Widerstand gegen die degradierenden Agente, andererseits durch eine Durchlockerung der kompakten Horizonten zum Ausdruck. Die Durchlockerung bedeutet eine Zunahme der Permeabilität und des Wasserhaltungsvermögen.

3. Der Einflusz der Lebewesen im Boden kann durch eine organische Düngung erhöht werden. In Baumgärten mit einer Grasnarbe kann dieses auch erreicht werden durch das Abmähen und die Verwesung des an Ort und Stelle liegen bleibenden abgemähten Grases.
4. Proteïnreiches organisches Material im Boden ermöglicht die Bildung von dunkel gefärbten stabilen Aggregaten durch Regenwürmer. Der strukturverbesserende Einfluss der Würmer ist am stärksten, wenn ihnen junges proteïnreiches Gras zur Verfügung steht; das Gras soll deshalb nicht zu hoch wachsen.
5. Stickstoff als Handelsdünger wirkt strukturverbesserend durch seinen Einfluss auf das Wachstum der Grasnarbe und die Würmtätigkeit. Der gegebene Stickstoff wird teilweise am Humus gebunden werden, die Kosten der Stickstoffgabe müssen deshalb nur teilweise als direkte Kosten und teilweise als Investierung betrachtet werden.
6. Bodenbearbeitung verbessert in diesem Fall die Struktur nicht. Nicht nur den lebenden Organismen wird durch die Bearbeitung Schaden zugefügt, sondern auch die Wasserbeständigkeit der Aggregate wird bedeutend niedriger, was durch einen Verlust an Stickstoff des Organischen Materials zu erklären ist.